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(54) **COMPRESSOR THROTTLING VALVE ASSEMBLY**

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(71) Applicant: **Ingersoll-Rand Company**, Davidson,  
NC (US)

(72) Inventors: **Thomas E. Gerber**, Williamsville, NY  
(US); **Mark R. Sabin**, Sanborn, NY  
(US)

(73) Assignee: **Ingersoll-Rand Company**, Davidson,  
NC (US)

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May 10, 2011, now Pat. No. 8,631,812, which is a  
division of application No. 12/643,262, filed on Dec.  
21, 2009, now Pat. No. 7,971,600, which is a  
continuation of application No. 12/534,822, filed on  
Aug. 3, 2009, now Pat. No. 7,637,282, which is a  
continuation of application No. 11/200,613, filed on  
Aug. 10, 2005, now Pat. No. 7,568,503.

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**F17D 3/00** (2006.01)  
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**F04B 49/22** (2006.01)  
**F16K 1/22** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **F04B 49/225** (2013.01); **F16K 1/221**  
(2013.01); **F16K 1/223** (2013.01); **Y10T**

#### (58) **Field of Classification Search**

CPC ..... F04B 49/225; F16K 1/221; F16K 1/223  
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137/613

See application file for complete search history.

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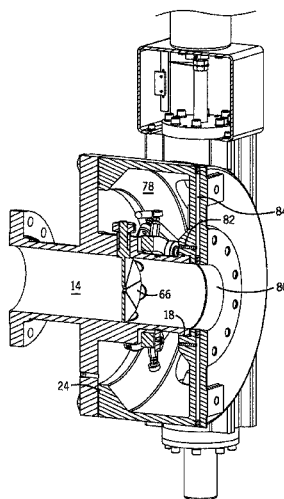
*Primary Examiner* — Kevin Lee

(74) *Attorney, Agent, or Firm* — Taft Stettinius & Hollister  
LLP

#### (57) **ABSTRACT**

A throttling valve assembly has an outer housing that is sealed. An actuator is connected to a pressure balanced shaft that extends into the housing to operate a plurality of linkages that can rotate blades in tandem. With the surrounding housing sealed, the shaft penetrations of the blade support shafts no longer need seals or a purge system to supply process gas during times of reduced pressure in situations with the blades nearly closed. A pressure equalization system has balance passages internal to the housing to allow flow from higher pressure zones to lower pressure zone of the process gas so as to avoid creation of a condition that can draw air into any zones of reduced pressure in the housing.

**20 Claims, 4 Drawing Sheets**



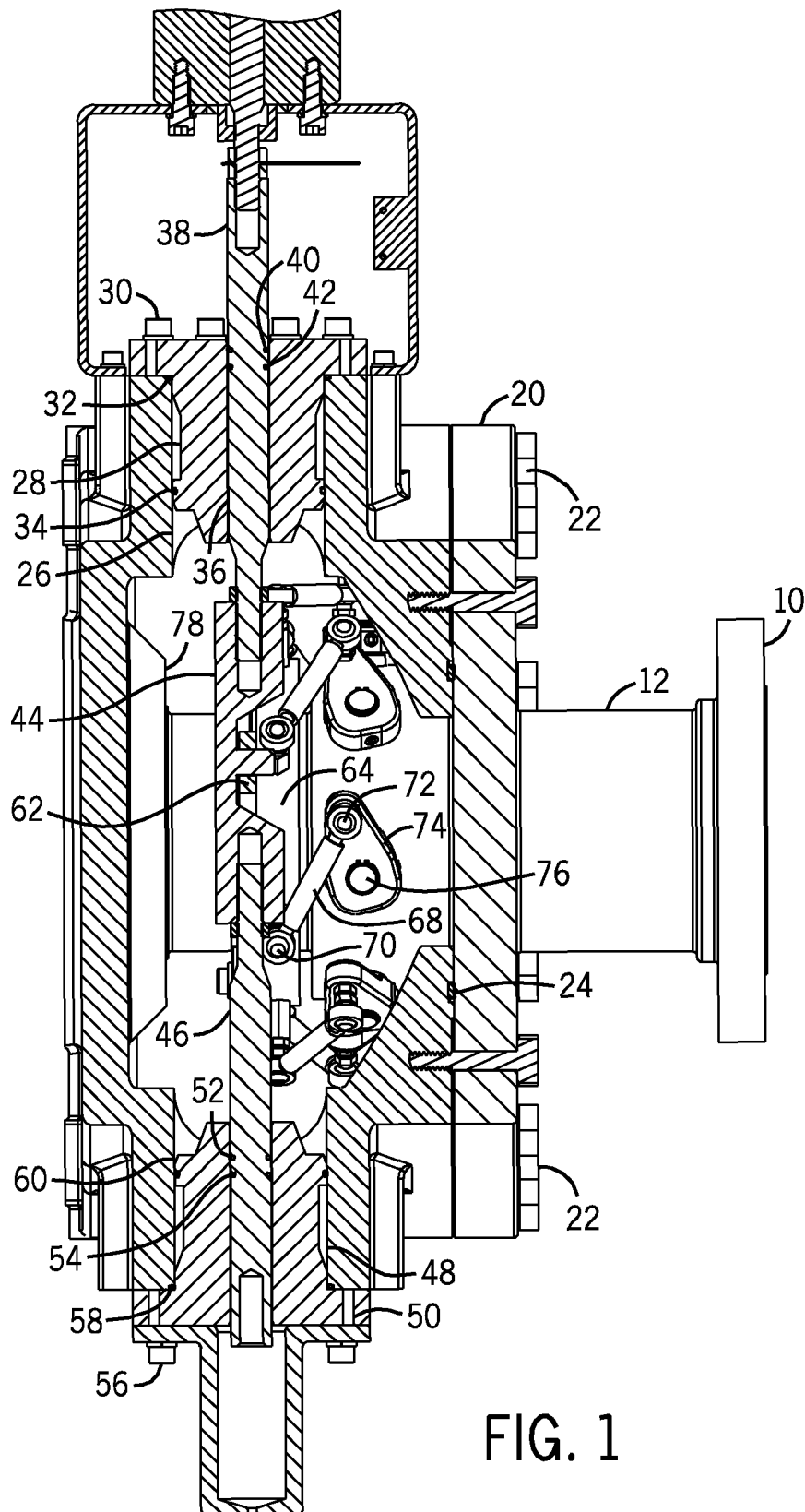
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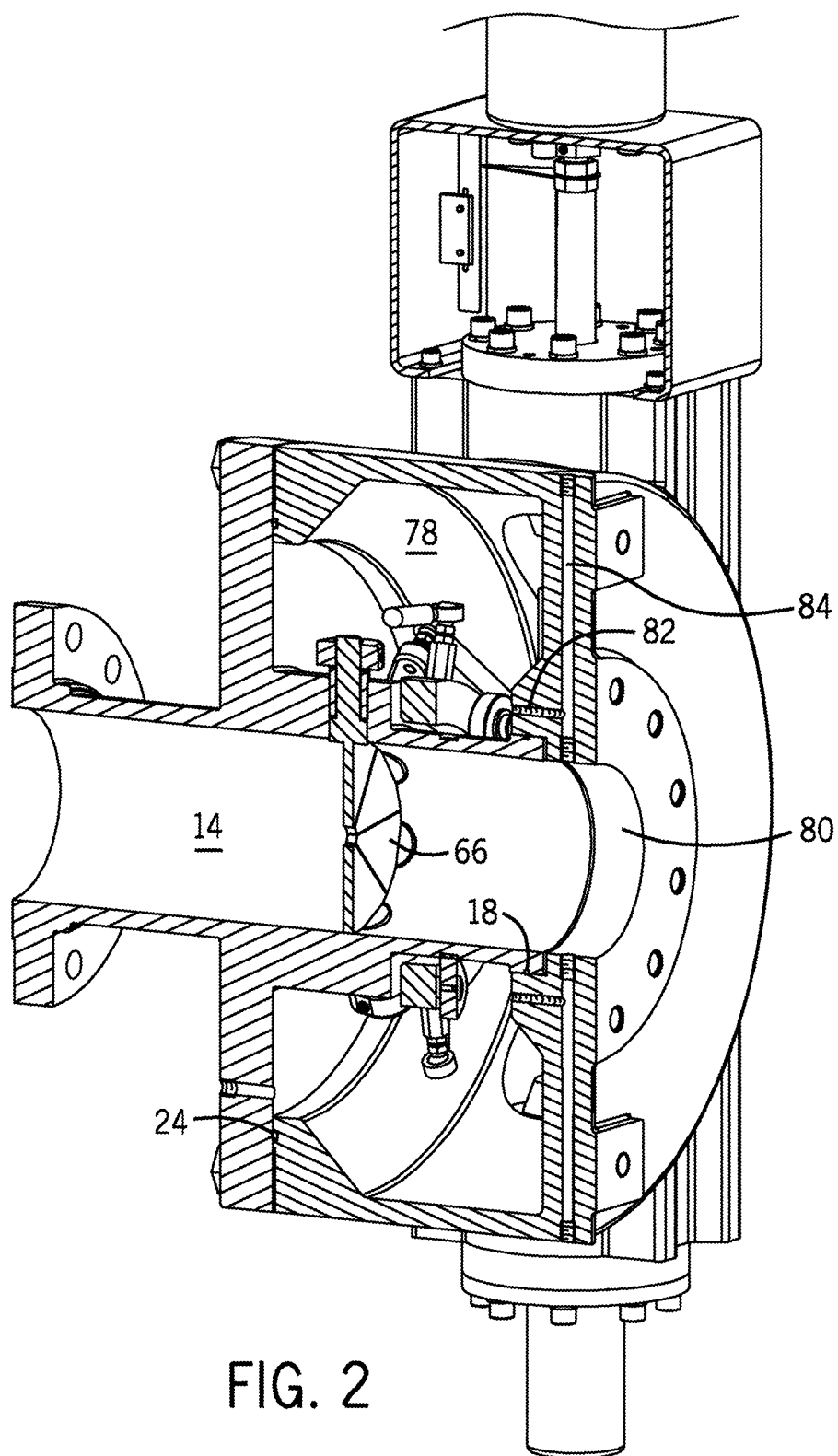


FIG. 2

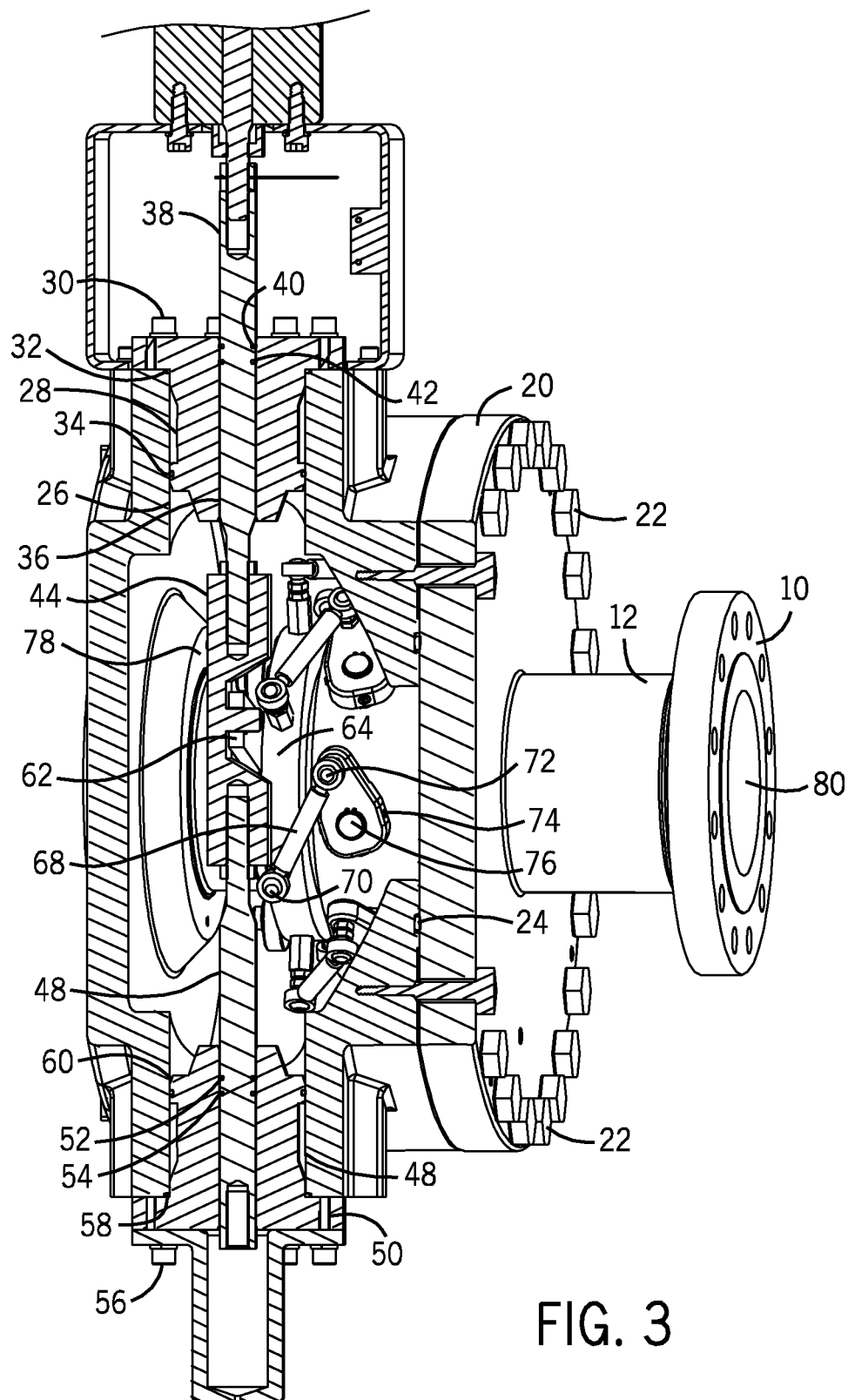
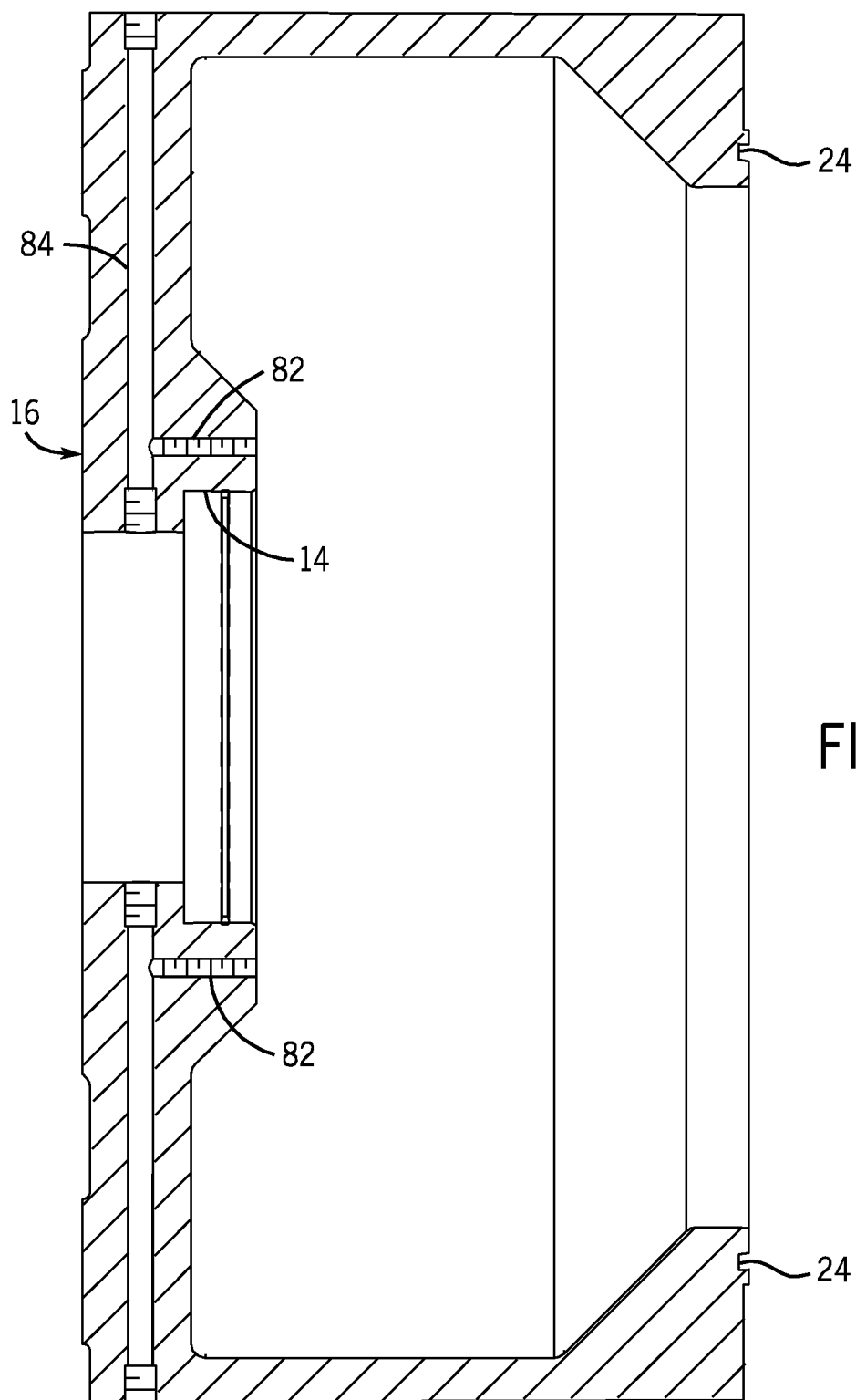


FIG. 3



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## COMPRESSOR THROTTLING VALVE ASSEMBLY

### CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/104,328, filed on May 10, 2011, now U.S. Pat. No. 8,631,812, and entitled "Compressor Throttle Valve Assembly", which is herein incorporated by reference in its entirety, and which is a divisional of U.S. patent application Ser. No. 12/643,262, filed on Dec. 21, 2009, now U.S. Pat. No. 7,971,600, and entitled "Compressor Throttling Valve Assembly", which is herein incorporated by reference in its entirety, and which is a continuation of U.S. patent application Ser. No. 12/534,822, filed on Aug. 3, 2009, issued as U.S. Pat. No. 7,637,282 on Dec. 29, 2009, and entitled "Compressor Throttling Valve Assembly", which is herein incorporated by reference in its entirety, and which is a continuation of U.S. patent application Ser. No. 11/200,613, filed on Aug. 10, 2005, issued as U.S. Pat. No. 7,568,503 on Aug. 4, 2009, and entitled "Compressor Throttling Valve Assembly," which is herein incorporated by reference in its entirety.

### FIELD OF THE INVENTION

The field of this invention is throttling valves and more particularly those used on centrifugal compressors to match output to system demands.

### BACKGROUND OF THE INVENTION

Centrifugal compressors are frequently packaged in multiple stages using a common drive including associated controls. One type of control involved throttling the suction to the initial stage so as to match the output of the compressor to the system demands. Doing this avoids the cost of energy to power the compressor units at output levels not required from the system. The nature of the performance curve of centrifugal compressors is that their output flow and pressure are related and can be varied by a throttling assembly typically mounted at the suction to the first stage. These throttling assemblies have been designed in the past using a series of blades that rotate 90 degrees between the open and closed position. Typically each blade has a pair of end shafts that extend out of the inlet piping going to the first stage. Each such shaft extension through the piping system was provided with a shaft seal and a purge system. The purpose of the purge system was to keep gasses from escaping these shaft seals particularly in applications where inlet pressures in a particular system ran normally at elevated pressures that were raised to an even higher pressure by the compressor system. The purge system served a purpose of avoiding sucking in surrounding air in some systems. In conditions of high turndown when the blades are operating close to the fully closed position, it was possible for the compressor to draw the pressure down to negative values. In those cases, in order to avoid drawing air into the process gas being compressed, the process gas was hooked to the purge system. If a negative pressure situation occurred, the process gas would be sucked in around shaft seals located at each end of each blade. Depending on the inlet piping size, there could be several blades rotating in tandem with each one having a connection to the purge system.

The blades each had a dedicated linkage typically connected to a rotating ring that was turned by an actuator, typically operated by pneumatic pressure.

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The problems with the prior design were numerous. As mentioned above there was the concern of leakage at every shaft seal of every blade and the need to hook up a purge system to each potentially leaking seal. The present invention eliminates the concerns of the previous designs by enclosing the inlet pipe with the blades inside in a surrounding housing. In this approach the leakage at blade shaft seals becomes irrelevant as a surrounding housing contains the process gas. The design further extends a balanced driving piston that is powered by the external pneumatic actuator into the interior of the housing. Balancing the piston reduces actuator output requirements by eliminating internal housing pressure as a load on the drive stem. Multiple seals are available on the drive stem penetrations of the housing to further enhance reliable operation. One or more internal passages remain open between the upstream and downstream sections of the housing on either side of the blades. Thus, when high turndowns with nearly closed blades bring the downstream pressure down to negative values due to continuing compressor operation, the passages serve an equalization function to avoid sucking air into the housing. These and other features of the present invention will be more readily understood from a review of the description and drawings of the preferred embodiment and the claims, which appear below.

### SUMMARY OF THE INVENTION

A throttling valve assembly has an outer housing that is sealed. An actuator is connected to a pressure balanced shaft that extends into the housing to operate a plurality of linkages that can rotate blades in tandem. With the surrounding housing sealed, the shaft penetrations of the blade support shafts no longer need seals or a purge system to supply process gas during times of reduced pressure in situations with the blades nearly closed. A pressure equalization system has balance passages internal to the housing to allow flow from higher pressure zones to lower pressure zone of the process gas so as to avoid creation of a condition that can draw air into any zones of reduced pressure in the housing.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a section view through the outer housing showing the shaft and linkage system that it operates;

FIG. 2 is a section through both outer and inner housings showing the blades;

FIG. 3 is another section showing the manner the linkages are operated in tandem by the shaft;

FIG. 4 is a section view through the outer housing.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 a compressor system (not shown) has its inlet attached at flange 10. Flange 10 is connected to inner housing 12 which is essentially a section of pipe that extends into a recess 14 (see FIGS. 2 and 4) of outer housing 16 and is sealed to said recess 14 with a seal 18. Attached to inner housing 12 is a flange 20 which is secured to outer housing 16 by bolts 22. A seal 24 seals the flange 20 to the outer housing 16. Outer housing 16 has an upper opening 26 which is closed off by a plug 28 secured in a sealing relationship due to bolts 30 and seals 32 and 34. A bore 36 accepts upper rod 38 which can translate in the bore 36 while being sealed to it by redundant seals 40 and 42. A connector 44 attaches lower rod 46 to upper rod 38. Opening 48 is opposed to opening 26 and accepts a plug 50 through which the lower rod 46 translates

while in a sealed relationship due to redundant seals **52** and **54**. Plug **50** is retained in a sealing relation to the outer housing **16** by use of bolts **56** and seals **58** and **60**.

Connector **44** is engaged to an arm **62** that extends radially from ring **64**. Translation of connector **44** results in rotation of ring **64**. Each blade **66** shown in FIG. **2** is connected to a linkage that comprises a link **68** pinned at **70** to ring **64** and pinned at **72** to link **74**. Shaft **76** is rotated with link **74** and the blade **66** turns when shaft **76** turns. All shafts **76** are designed to rotate in tandem to operate each blade **66** in tandem and uniformly. FIG. **2** shows the blades **66** in the closed position.

The extensions of shafts **76** through inner housing **12** are no longer needed to be sealed as in the prior art. This is because there is an outer housing **16** that has its orifices sealed with flange **20**, plug **28** and plug **50**.

An annular space **78** is created between outer housing **16** and inner housing **12**. Outer housing **16** has an upstream inlet **80** that leads to the blades **66** in the inner housing **12**. Pressure in inlet **80** communicates through passage **82** into the annular space **78**. That way when the blades **66** go toward the closed position reducing the pressure in the inner housing **12** near flange **10** gasses from annular space **78** flows around shafts **76** so that outside air is not drawn into the inner housing **12**. Passage **84** is provided and can be blanked off on outer housing **16**. Alternatively, a purge system that can deliver process gas into annular space **78** may still be wanted by some users and they can use passage **84** for that very purpose.

Those skilled in the art will appreciate that the pressure balanced design of upper rod **38** and lower rod **46** makes the driving assembly insensitive to annular space **78** pressure. The redundancy of seals such as **40** and **42** means more hours of reliable operation and less downtime. The pressure balanced design allows the use of a smaller actuator connected to upper rod **38**. The pressure equalizing system has no moving parts and equalizes pressure differentials induced by reorientation of the blades **66** fairly fast. The design eliminates shaft seals on the rotating blade or blades **66**. The two piece design of the outer housing **16** facilitates maintenance and assembly operations. Seals on rods **38** and **46** can be changed without taking the housing **16** out of the suction piping system to the compressor. Thrust loads on the shafts **76** are reduced if not eliminated since annular space **78** and inner housing **12** quickly equalize to a common pressure upstream of the blades **66**.

While the preferred embodiment has been set forth above, those skilled in the art will appreciate that the scope of the invention is significantly broader and as outlined in the claims which appear below.

The invention claimed is:

1. A system, comprising:
  - a flow control device, comprising:
    - a plurality of flow control members;
    - a plurality of linkages coupled to the plurality of flow control members;
    - a common linkage coupled to the plurality of linkages;
    - a first shaft coupled to the common linkage; and
    - a second shaft coupled to the common linkage;
 wherein the flow control device comprises a housing having a chamber, wherein the plurality of linkages and the common linkage are disposed in the housing.
2. The system of claim 1, wherein the plurality of flow control members are disposed external to the housing.
3. The system of claim 2, wherein the housing has a fluid passage in fluid communication with a fluid region having the plurality of flow control members external to the housing.
4. The system of claim 2, wherein the flow control device comprises a plurality of shafts interconnecting the plurality of

linkages with the plurality of flow control members, wherein the plurality of shafts extend through the housing.

5. The system of claim 4, wherein the plurality of shafts are sealed relative to the housing.

6. The system of claim 4, wherein at least one of the plurality of shafts is not sealed relative to the housing.

7. The system of claim 1, wherein the first shaft is configured to move into the chamber of the housing while the second shaft moves out of the chamber of the housing, and the second shaft is configured to move into the chamber of the housing while the first shaft moves out of the chamber of the housing.

8. The system of claim 1, wherein the chamber maintains a constant volume.

9. The system of claim 1, wherein the common linkage comprises a ring.

10. The system of claim 9, wherein the first and second shafts are coupled to the ring.

11. The system of claim 10, wherein the first and second shafts are configured to reciprocate in opposite directions relative to one another to move the plurality of valve members between open and closed positions.

12. The system of claim 1, wherein the housing extends about a fluid flow path, and the plurality of flow control members are disposed in the fluid flow path.

13. The system of claim 1, wherein each flow control member of the plurality of flow control members is coupled to a shaft, a first linkage of the plurality of linkages is coupled to the shaft, a second linkage of the plurality of linkages is coupled to the first linkage, and the common linkage is coupled to the second linkage.

14. The system of claim 13, wherein the common linkage comprises a ring.

15. The system of claim 1, comprising an actuator coupled to the flow control device.

16. The system of claim 1, comprising a compressor coupled to the flow control device.

17. A system, comprising:
 

- an actuator;
- a plurality of linkages coupled to the actuator;
- at least one shaft coupled to the plurality of linkages; and
- a housing having a chamber, wherein the plurality of linkages are disposed in the chamber, and the at least one shaft is configured to move in and out of the chamber while maintaining a constant fluid volume within the chamber.

18. The system of claim 17, wherein the at least one shaft comprises first and second shafts, the first shaft is configured to move into the chamber of the housing while the second shaft moves out of the chamber of the housing, and the second shaft is configured to move into the chamber of the housing while the first shaft moves out of the chamber of the housing.

19. A system, comprising:
 

- an actuator;
- a plurality of linkages coupled to the actuator;
- at least one shaft coupled to the plurality of linkages;
- a housing having a chamber, wherein the plurality of linkages are disposed in the chamber; and
- a fluid leak path through the housing from an external fluid region into the chamber, wherein the fluid leak path is configured to enable pressure exchange between the external fluid region and the chamber.

20. The system of claim 19, wherein the external fluid region is pressurized, and the fluid leak path is configured to pressurize the chamber with fluid pressure in the external fluid region.